Research results

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○Higher-dimensional black holes with compact extra dimensions [1-22, 24]

Higher-dimensional black hole spacetimes are actively discussed in the context of string theories and braneworld models. If higher-dimensional black hole solutions have compactified extra dimensions, we can regard such black hole solutions as candidates of realistic models, since our observable world is effectively four-dimensional. We call these Kaluza-Klein black holes. In four-dimensional general relativity, the gravitational field in vacuum with spherical symmetry is uniquely described by the Schwarzschild metric. However, in a higher-dimensional spacetime with Kaluza-Klein structure, even if we impose asymptotic flatness in a four-dimensional section, the metric is not determined uniquely. It is an interesting task to study what kind of black holes exist in such spacetimes and how observational verification can be done. However, since the spacetime symmetries become less, it is not easy to construct an exact solution which represents a Kaluza-Klein black hole. Introducing a twisted compact extra dimension, we find a family of five-dimensional squashed Kaluza-Klein black hole solutions, which asymptote to effective four-dimensional spacetimes with an S^1 at infinity and represent fully five-dimensional black holes near the squashed S^3 horizons. Then squashed Kaluza-Klein black hole solutions with a twisted compactified extra dimension would describe the geometry around the compact objects. Several aspects of squashed Kaluza-Klein black holes are discussed, for example, multi-black holes, stabilities, Hawking radiations, quasinormal modes, thin accretion disk, X-ray reflection spectroscopy, gyroscope precession, strong gravitational lensing, black hole shadow and light deflection.

○Particle acceleration by ion-acoustic solitons in plasma [23]

We propose a new acceleration mechanism, soliton acceleration, for charged particles by using cylindrical or spherical nonlinear acoustic waves propagating in ion-electron plasma. The acoustic wave, which is described by the cylindrical or spherical Korteweg-de Vries equation, grows in its wave height as the wave shrinks to the center. Charged particles confined by the electric potential accompanied with the shrinking wave get energy by repetition of reflections. We obtain power law spectrum of energy for accelerated particles. As an application, we discuss briefly that high energy particles coming from the Sun are produced by the present mechanism.